

Full length paper

**PUBLIC PERCEPTIONS TOWARDS MACAQUE POPULATION ALONG THIMPHU-
PHUENTSHOLING HIGHWAY: IMMINENT PUBLIC HEALTH AND CONSERVATION THREATS**

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ABSTRACT: Currently, there are seven species of primate recorded in Bhutan. Two species of primates namely the Assamese macaque (*Macaca assamensis*) and the Hanuman langur (*Semnopithecus entellus*) are commonly sighted in the western region of the country. There are reports of increasing macaque population along the Thimphu-Phuentsholing highway, with few stray reports on interaction between humans and monkeys. Given the similarity in genetical, physiological and behavioural characteristics, interactions between monkeys and humans can facilitate cross-transmission of pathogens. Pathogen swapping can not only threaten the public health but also pose a potential conservation threat. This study was conducted as an approach to understand the perception of the people on the macaque population along the highway, geo-locate the areas where macaques are commonly sighted, and review the zoonotic pathogens that can be cross transmitted between humans and macaques. The study interviewed 129 participants along the highway using a questionnaire to understand their perception. For reviewing the zoonotic diseases, literatures were collated from google scholar using search terms “macaque” and “zoonosis”. More resources were acquired by checking the references of literature obtained from the google scholar search. Majority of the participants had high tolerance towards macaque in their community. Of the participants who have seen monkey in their locality (n=71), 17 (14%) could recall seeing some form of interactions (people killing monkeys, monkeys biting people) between humans and monkeys while 45 (36%) of them have seen interaction between dogs and monkeys. Hundred and fourteen participants reported that the monkey population is increasing along the highway and 99 (89%) of the participants thought it was due to people feeding food. The study recorded 19 geo-coordinates along the Thimphu-Phuentsholing highway where the macaques were commonly sighted. The literatures review recorded 14 viral diseases, 8 bacterial diseases, 11 parasitic diseases and a fungal disease that are of concern when considering the human macaque interaction. This study provides a preliminary evidence of the people’s perception towards monkey population along the Thimphu-Phuentsholing highway and their level of knowledge about the zoonosis associated with macaques. This study also provides geo-location of the common areas where the macaques are commonly sighted which can be useful in displaying public notices for garnering compliances. Furthermore, this study provides an overview of the common zoonoses that are of concern when considering the human macaque interaction.

Keywords: Human-wildlife-interaction; *Macaca assamensis*; monkeys; zoonoses.

1. INTRODUCTION

Interaction between human and macaques occur for various reasons. While they play a significant socio-

cultural and religious role in certain parts of the world such as India and Nepal (Jones-Engel et al. 2006; Pragatheesh 2011), they are often sought as a source of food and their meat for medicinal values in other parts of

the world (Walker 2010; Muehlenbein 2017). Furthermore, interactions occur when they are kept as companion animal and displayed for tourist attraction (Muehlenbein 2017). Such interactions can facilitate cross-transmission of diseases between human and primate population posing public health and conservation threats. Furthermore, uncontrolled monkey population can be a reason for serious social nuisance as reported from India and south east Asia (Kreston 2014; Tapper 2014). A total of 1415 species of infectious agents in 472 genera have been reported to cause disease in humans. Of these 868 (61%) from 313 genera are known to be zoonotic. A total of 175 species of infectious agents from 96 genera are associated with emerging disease (Taylor et al. 2001).

Most of the microbes that have evolved to infect humans have its origin from the animal species (Cleaveland et al. 2001). Several factors can be attributed to the infectious agents' ability to cross species barrier which include those related to the host, the infectious agents and the environment. Owing to the similarity between humans and non-human primates in terms of genetic, physiological and behavioural characteristics, the non-human primates are considered high-risk sources of infectious agents with the capacity to infect humans. Recent incidences of epidemics in humans because of non-human primate origin infections are Ebola and zika virus.

With around 60% of the country under forest coverage, Bhutan is considered as one of the bio-diversity hotspots in the world. There are seven recorded primate species in Bhutan namely, the slow loris (*Nycticebus bengalensis*), Assamese macaque (*Macaca assamensis*), Rhesus macaque (*Macaca mulatta*), Hanuman langur (*Semnopithecus entellus*), golden langur (*Trachypithecus geei*), and capped langur (*Trachypithecus pileatus*) (Choudhury 2008). In the western parts of the country the Assamese macaque and the Hanuman langur are commonly sighted. While there have been home range studies carried out for the Assamese macaque in the western region, no studies have been conducted to detect any infectious agents of zoonotic concern.

Furthermore, despite the informal reports of growing macaque population along the western highway, no studies have been conducted to understand people's perception toward macaque along the highway and their knowledge about diseases that can be cross transmitted between humans and the macaques.

Therefore, the objectives of this study are to and to 1) understand public perception on the monkey population between Thimphu and Phuentsholing national highway 2) geo-locate places where monkeys are sighted along the highway and 3) review some of the important zoonotic diseases that are cross-transmitted between humans and macaques.

2. MATERIALS AND METHODS

2.1 Study area

Western region has five client Dzongkhags under its technical jurisdiction namely, Thimphu, Paro, Haa, Chukha, Samtse. Both the capital city of Bhutan, Thimphu and the major commercial hub, Phuentsholing under Chukha Dzongkhag lies under the Western region. These places are connected by a national highway. Assamese macaques are present along this highway. Therefore, people residing along this highway was included for the interview.

2.2 Survey questionnaire

A questionnaire comprising four different sections was prepared and used for data collection. Section one comprised questions regarding the participants' information while the section two comprised questions relating to interactions between humans and macaques. Section three comprised questions related to participants knowledge about disease transmission between macaques and humans and the fourth section comprised question relating to the participants perception and practices. Both open ended and close ended questions were used in the questionnaire.

Four livestock personnel working in Regional Livestock Development Centre (RLDC), Tsimasham were recruited and trained as enumerators. The questionnaire was pretested during mock interviews and modified accordingly to improve clarity. The questionnaire was enumerated during the month of March 2019 by visiting only the accessible household along the highway. One of the adult members in households who were 18 years and above were included for the interview. Prior to start of the interviews, the objectives of the study were explained to the participant and subsequently an oral consent was sought.

2.3 Review of zoonosis

The zoonotic diseases that are transmissible between non-human primates, especially between macaques and the humans were reviewed and information relevant to this study were referred.

2.4 Statistical analysis

The researchers drove thrice along the Thimphu - Phuentsholing highway to map geo-coordinates of locations where monkeys were spotted. During each visit, the coordinates where the monkeys were spotted were recorded using google maps app in Samsung s-6 cellular phone.

The coordinates were then managed in the MS Excel worksheet (Microsoft excel 2013, Redmond, USA) and projected on the western region shapefile and a map was generated using Quantum GIS software (QGIS

Development Team 2017) (Figure 2). The Thimphu-Phuentsholing stretch is around 151 kms.

The data gathered during the survey were descriptively analysed.

3. RESULTS

3.1 Socio-demographic characteristics

In total, 129 participants were interviewed in the study area. One-hundred and three (80%) were females and 26 (20%) were males. The mean age of the participants was 38 years. Ninety-three (74%) were engaged in some form of business, 31 (24%) farmers, 1 govt employee and 1 student. Seventy-one (55%) of them had not attained any formal education. 96 (74%) of the participants owned animals of which 42 owned pet and rest livestock for production purpose.

3.2 Interactions with macaques and knowledge about disease transmission

In total 125 (97%) participants have seen monkeys near their residence. Majority of the participants, 71 (57%) have seen monkey in their locality since more than 10 years and the rest for 10 years (Figure 1). Of these, 17 (14%) could recall some form of interactions (people killing monkeys, monkeys biting people) between humans and monkeys while 45 (36%) of them have seen

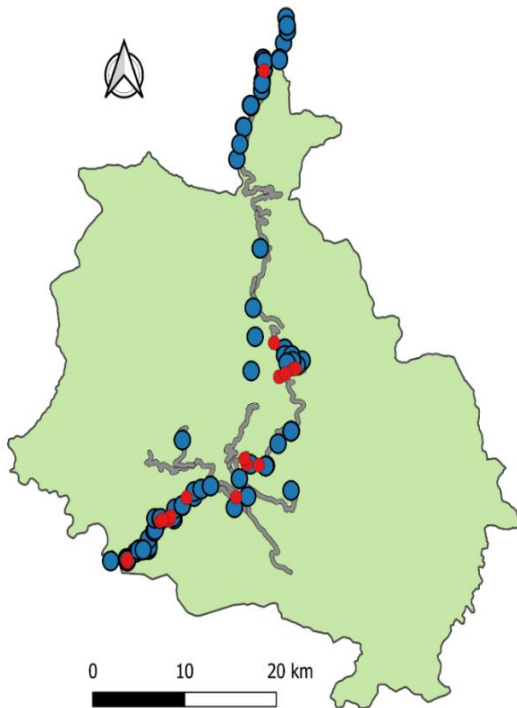


Figure 1: Map of Chukha showing the Phuentsholing-Thimphu highway (grey coloured), households surveyed along the highway (blue dots), and locations of monkey sighting (red dots)

interaction between dogs and monkeys. Fifty (42%) participants reported that humans can contract diseases from monkeys while 51(40%) were not sure if humans could contract disease. Twenty participants reported that humans cannot contract disease from the monkeys.

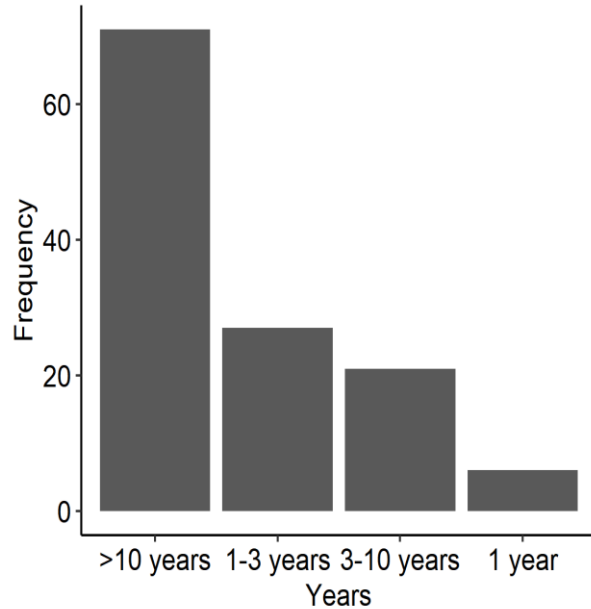


Figure 2: Number of years people have been seeing macaques in their locality

3.3 Participants' practices and perception

In total, 29 participants reported that they had a very high level of tolerance towards monkeys' presence in their locality while 86 said they had a high level of tolerance. Only 14 of them reported to have low tolerance on seeing monkeys in their locality. Of the total participants, only 16 of them reported feeding monkeys while 93 (72%) participants reported seeing people feeding monkeys along highway. The participants reported that 91 (98%) of the people who they saw feeding monkey were Bhutanese travellers while one was tourist and the other one roadside vegetable vendor. Hundred and fourteen participants reported that the monkey population is increasing along the highway while 8 of them said that there is no increase in the population. Five of the participants were not sure about the population status of the monkey. Of the two reasons that were provided to be chosen as the most relevant reason for the increasing monkey population, 99 (89%) chose "people feeding" while 4 chose "deforestation". Rest of the participants were not sure of a reason for the growing monkey population. Of the 127 participants (2 missing), 120 participants felt that the growing monkey population along the highway was a problem while 7 reported it was not. Most of the participants think that the community

should come forward and take responsibilities in controlling the growing monkey population while almost equally, participants think it is the government's responsibility.

3.4 Geo-coordinates of the areas where monkeys were sighted, and interview conducted

Monkeys were sighted at 20 locations along the Thimphu-Phuentsholing highway (Figure 1). Between Chukha and Thimphu stretch, monkeys were sighted only in one location before reaching to Chuzom (confluence); whereas, the sighting increased between the Chukha and Phuentsholing stretch. The sightings located were the aggregate of the three times travel along this highway. Monkeys were not sighted in all locations during a single travel. The study also observed people feeding monkeys, roadkill of an adult macaque, and free-roaming dogs feeding on monkey carcass along the highway.

3.5 Review of important zoonosis associated with macaques

A total of 20 papers were reviewed in addition to collecting information from four other webpages regarding the zoonoses of non-human primates. It is critical to understand that not only can the non-human primates be the source of diseases to humans, equally humans can transmit diseases that non-human primates are susceptible and can pose potential conservation threats (zooanthroponosis). There are currently about 376 species of non-human primates (OIE terrestrial Animal Health Code 2018). While there are so many diseases that

can be cross transmitted between non-human primates and humans, the study listed diseases that are relevant to the macaques. Table 2 presents some of the important viral pathogens that can be transmitted from macaques to the humans such as rabies, herpes simiae, simian virus 40, simian type D retrovirus, Simian T-cell lymphotropic virus type 1 (STLV-1), Simian hemorrhagic fever, Rota virus, Monkey pox virus, Hepatitis A, and Measles (Emerging Infectious Diseases 1998; Engel et al. 2002; Huff and Barry 2003; Switzer et al. 2004; Jones-Engel et al. 2005; Conly and Johnston 2008; Brinton et al. 2015; OIE terrestrial Manual 2018). While some of the significant bacterial pathogens reported (Table 1) are *Campylobacter jejuni*, *Salmonella sp.*, *Shigella sp.*, *Leptospira interrogans*, *Streptococcus pneumoniae*, *Mycobacterium tuberculosis* and *Haemophilus influenzae* (Nath et al. 2012; OIE terrestrial Manual 2018). In addition, there are also some ecto and endo parasites such as *Anaplasma phagocytophilum*, *Plasmodium sp.*, *Entamoeba sp.*, *Giardia sp.*, *Chilomastix sp.*, *Ascaris sp.*, *Strongyloides sp.*, *Ancylostoma sp.*, *Trichuris sp.*, *Oesophagostomus sp.*, *Enterobius sp.*, and *Hymenolepis sp.*, that can be transmitted between macaques and humans (Nakayima et al. 2014; Faust and Dobson 2015; Li et al. 2015; Maharajan 2015; Begum et al. 2018; Dixit et al. 2018).

4. DISCUSSION

The study was conducted to assess the public perception towards macaque population and review some of the

Table 1: Some of the important bacterial diseases that can be transmitted to human / swapped between humans and macaques

Pathogen	Transmission mode	Remarks
<i>Campylobacter jejuni</i>	Contaminated food and water	
<i>Salmonella sp.</i>	Contaminated food and water	
<i>Shigella sp.</i>	Contaminated food and water	
<i>Leptospira interrogans</i>	Skin abrasion and visible mucous membranes	
<i>Streptococcus pneumoniae</i>	Aerosolized droplets, close contact	
<i>Mycobacterium tuberculosis</i>	Aerosolized droplets	
<i>Haemophilus influenzae</i>	Aerosolized droplets	
<i>Plasmodium sp.</i>	Mosquito bites	(Maharajan 2015)
<i>Entamoeba sp.</i>	Contaminated food and water	
<i>Giardia sp.</i>	Contaminated food and water	
<i>Chilomastix sp.</i>	Ingestion of cysts in contaminated water, food, or by the fecal-oral route	
<i>Ascaris sp.</i>	Ingestion of eggs in contaminated water, food, or by the fecal-oral route	
<i>Strongyloides sp.</i>	larvae enter the body through exposed skin, such as bare feet	
<i>Ancylostoma sp.</i>	larvae enter the body through exposed skin, such as bare feet	
<i>Trichuris sp.</i>	Ingestion of eggs in contaminated water, food, or by the fecal-oral route	
<i>Oesophagostomus sp.</i>	Ingesting infective larva	
<i>Enterobius sp.</i>	Faeco-oral route	
<i>Hymenolepis sp.</i>	Ingestion of eggs in contaminated water, food, or by the fecal-oral route	
<i>Trichophyton</i>	Direct and indirect contact (fomites)	

potential public health consequences that would result from the increasing interactions between macaques and human. Several informal reports of people feeding macaques, macaque attacks and increasing population along Thimphu-Phuentsholing highway have been made on the social media such as Facebook. While there are no past records to compare and assess the absolute growth in monkey population, majority of the participants reported that macaque population along the highway is increasing. Supporting to the common observation during the one-month study period, participants reported people feeding the monkeys as one of the common reasons for the population growth. This may not be an absolute increase in the macaque population *per se* but an increase in the population that have now started residing by the highway due to easy access to food. Assamese macaques are omnivorous, and plants form the major part of their diet (Zhou et al. 2011; Norbu et al. 2016; Koirala et al. 2017). However, humans feeding monkeys can alter the feeding behaviour and activity budget of the macaques (Koirala et al. 2017)). As they don't have to move around in search for food, they spend more time along the highways which in turn provides opportunity for close interactions with humans. This could be the reason why they are frequently

spotted along the highway compared to the past when vehicle plying along highway was relatively less and so was the number of humans providing food to the monkeys.

Participants reported observing some form of interactions between humans and macaques and macaques and dogs. However, it was observed that most of the participants didn't know that humans can contract diseases from macaques. Close interactions between humans and macaques can facilitate exchange of a wide range of pathogens and have detrimental consequences on the health of both species (Koirala et al. 2017). Furthermore, interactions between macaques and dogs can lead to spread of rabies, which is a commonly reported notifiable zoonotic disease in dogs, in the macaque population. Although macaques are not a known reservoir for rabies and cannot transmit rabies to other species, their social behaviour of grooming and dominance demonstration through fights can facilitate rabies transmission within the macaque population posing a potential conservation threat.

Participants report of a high tolerance towards monkey and observing Bhutanese travellers as the most common food provider for the macaques can be attributed

Table 2: Important virus (diseases) that can be transmitted to human / swapped between humans and macaques

Pathogen	Transmission mode	Remarks
Rabies	Bite, scratches	
Herpesvirus simiae Simian virus 40	Bites and scratches (Huff and Barry 2003) Contact with urine and body fluids (Jones-Engel et al. 2006)	Associated with cancer formation
Simian type D retrovirus	Through direct contact between infected and susceptible animals, or indirectly through contact with contaminated instruments or equipment (e.g. tattoo needles, transfer boxes, dental instruments, or gavage tubes)	Virus is shed in saliva hence mutual grooming or aggressive interactions involving biting and scratching
Simian T-cell lymphotropic virus type 1 (STLV-1)	bites, scratches and mucosal splashes (Conly and Johnston 2008)	
Simian Foamy Virus (SFV)	bites, scratches and mucosal splashes (Conly and Johnston 2008)	
Rhesus Cytomegalovirus		Growth of RhCMV in human cells has been demonstrated in vitro however no human infection with RhCMV has been reported (OIE terrestrial Manual 2019).
Simian hemorrhagic fever KFD virus	Bites, direct and indirect contacts Ticks	
Rota virus	Fecal-oral route	
Monkey pox virus	Contact with the virus from an animal, human, or materials contaminated with the virus	
Hepatitis A	fecal-oral route or consumption of contaminated food or water	
Measles	Aerosolized droplets	

to mythological association of monkey to the Buddhist and Hindu religion. Majority of the Bhutanese population are Buddhist followed by Hindu. Therefore, this finding underscores the need for awareness education among the travellers (Bhutanese and tourist) regarding the potential consequences to the health of humans and macaques that would result from feeding the macaques. Awareness education should also be designed to the public transport drivers as they are the ones who ply most along the highway.

Most of the participants reporting that the communities should be taking lead in applying mitigation measures to control the growing monkey population along the highway indicates the willingness to share responsibilities with the relevant government agencies and take ownership. Therefore, initiatives should be undertaken to engage communities and give ownerships to the communities to apply measures that can discourage anthropological activities leading to growing macaque population along the highways. Implementing strict measures will require commitment and support from different sectors such as the National Environment Commission, local community, Department of Forest and Park Services, Department of Livestock, and municipal corporations.

The study recorded the coordinates of the areas where the monkeys were spotted along the highway. However, monkeys are not spotted in all the locations recorded during the visit. This could be because the monkeys must be staying in different areas along the stretch depending on the time of the day and food availability. (Norbu et al. 2016) reported rather a large home range group of the macaques that were tagged with radio-collars. The coordinates recorded during the study would however be of great value to display notices and share information for the travellers to comply with, especially requesting them not to feed macaques and other wildlife.

Convenience sampling was administered for interviewing people along the highway. As the participants of this study doesn't represent the whole population along the highway, caution needs to be placed in generalizing the findings of the study. Due to inaccessibility to published articles, we could only review papers that were accessible. Furthermore, the search method the study adopted was not robust and must have missed articles that were accessible. In this process, the study might have also missed out important diseases that are of relevance in the pretext of macaque and human interaction. Although the study presents a list of zoonotic pathogens that can be swapped between humans and Macaques (Table 2); currently, there is no data on the pathogens that macaques harbour along the highway. To ensure targeted awareness, intervention and contingency plans are developed, it is essential to know the prevalence of zoonotic pathogens in the macaque population. Such

researches can be clubbed with studies that are being conducted by Department of Forests and Park Services (DoFPS) to understand the home range, feeding behaviours, morphological and genetic characteristics of the Assamese macaque (Norbu et al. 2016).

5. CONCLUSION

This study shows that there is interaction between the human population and the macaques along the Thimphu-Phuentsholing highway. Furthermore, from the interview, it has been determined that people think there is increase in the population of macaques along the highway. The increasing presence of macaques can be associated with the human behaviours and thus there is need to design strategies to control growing macaque population along the highways targeting the change in current practices of travellers. Implementing effective measures to reduce the presence of macaques along the highway has the benefit of enhancing conservation of the macaque population as well as averting risk that can result from cross transmission of pathogens between humans and macaques.

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